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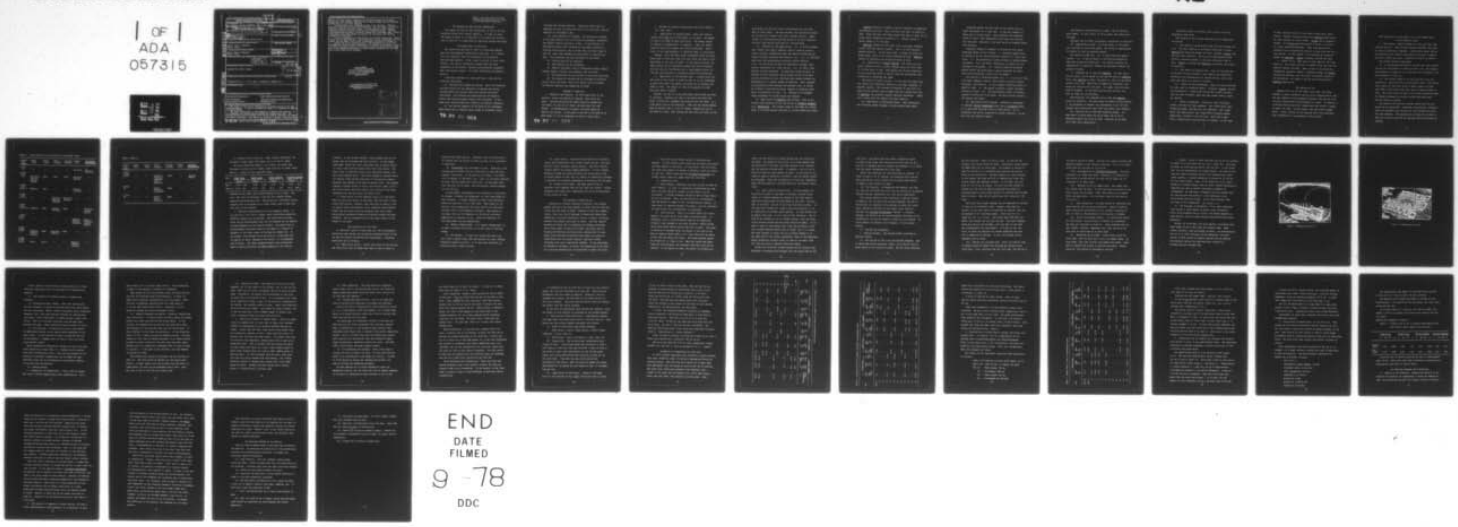

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The supply of fish fry and fingerlings is of primary concern to the fish culturing industry. In order to increase the supply, it is necessary to improve rearing techniques.

The first of many parts to this program is to improve pond condition. It is recommended that rearing ponds be drained and cleaned once a year. The cleaning process involves treatment with various chemical substances, and simple mud removal (dredging). This reduces the incidence of disease, eliminates pest

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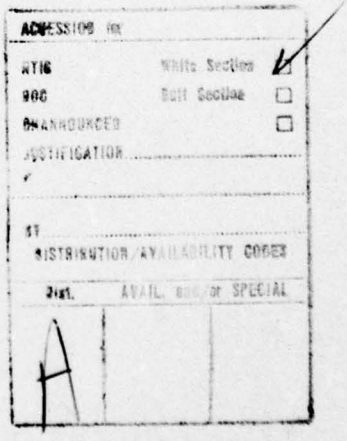
species and other harmful organisms, and facilitates repair of the pond's structure. Many different chemicals can be used, although lime and bleaching powder seem to be the most effective.

The second area to be considered is that of fry nutrition. Different species of fry have different food preferences. For this reason, they can be found in different areas of the pond. For each species of fish, slightly different pond and fertilizer conditions are considered optimal. The basic fertilizers used are grass, cow manure, soybean milk, and peanut cakes. Recent experiments using human sewage have proven very successful, with exciting prospects for the future.

A third consideration is the selection of a suitable rearing pond. Characteristics of a good pond are: ~~has~~ an ample water source, appropriate size and depth, circular shape, level bottom, non-leaking, and plenty of sunlight.

Another part of the rearing process is the preparation of the fry for transportion, otherwise known as hardening. The purpose of hardening is to get the fish to excrete as much of their mucus and feces as possible before being put in the transporting container, so these harmful substances will not build up to toxic levels in the container.



Tables 1 and 4 were left out of the document purposely per Mr. E. O. Gangstad, Office, Chief of Engineers

THE REARING OF FISH FRY AND FINGERLINGS

The supply of fish fry and fingerlings is one of the key questions facing fish culture industry. In order to solve the supply problem, it is necessary to increase the survival rate of fish fry to fingerlings by improving rearing technique.

The Importance of Pond Care

The growth and survival of fish in a fish pond depends upon the environmental conditions in the pond. It is therefore very important that the conditions of the pond be improved periodically. After a year's culture of fish, food residue, fish feces, and material washed from the land accumulate on the bottom. Bacteria and parasites propagate; pest fish species remain. All these conditions are negative factors.

A thorough cleaning of a fish pond once a year has the following advantages:

(1) The pond will become fertilized. After the draining, the pond bottom will be subjected to freezing and drying, thereby making the surface layer more porous and better ventilated. This hastens the mineralization of decaying matter and converts organic matter into nutrients. At the same time, some microbes are killed by ultraviolet radiation.

(2) The rearing capacity of the pond can be increased. When bottom mud is removed, pond volume is increased, which

increases the rearing capacity. Experience shows that by removing one foot of bottom mud from a 5-6 foot pond, rearing capacity is increased by 30%.

(3) Fish diseases are reduced. The drying and cleaning of the pond usually kills off bacterial pathogens, parasites, and aquatic insects and their larvae. In one district of Chekiang Province, such cleaning of fish ponds resulted in lowering the mortality rate of grass carp and black roach to only 3%, lower than neighboring areas where no cleaning was done. The production was also increased to 200 kg/ha.

(4) Leaking pond can be repaired.

(5) Pest species can be eliminated.

(6) Harmful organisms, such as filamentous algae, aquatic plants, aquatic insects, and tadpoles, can be killed.

(7) The bottom mud can be utilized to fertilize farm land.

(8) The volume of the pond can be increased by building up the rim of the pond. This is an easier way to increase the rearing capacity than deepening the pond.

Methods of Pond Care

1. Method of mud removal. At 20-30 days prior to fry planting, bottom mud should be removed. Then drain the water. Settled mud along the banks should be spread over the banks, let dry for 2-3 days, then pat down flat and smooth. If sedimentation is slight, draining should be done in the winter. If the pond is new and if the pond is in good shape, it is not necessary to drain it every year.

2. Methods of chemical applications and their effects.

(1) Lime (CaO).

i. Application in drained ponds. After mud removal, retain some water (2-3 inches deep) in the pond. the amount of lime to be used is about 1000 kg/ha. The amount should be reduced if sedimentation is apparent. Lime will absorb moisture easily and change into calcium hydroxide. Therefore, if not used promptly, it should be kept in a dry place.

Method: Dig a few small pools scattered around the pond. Then place in each pool some lime and, while the water is hot, distribute it all over the pond. In the place of pools, the same results can be obtained by dissolving lime in buckets. The next day stir the bottom with a long handled stirrer so that the lime solution is thoroughly mixed with bottom mud.

ii. Application in non-drained pond. In ponds which are not close to any rivers or lakes so that it is not convenient to drain and refill the ponds, the ponds can be treated with water in them. The amount of lime to be applied is 1200 kg/ha per meter of depth.

Method: One way is to dig some small pools along the side of the pond. Dissolve the lime in the pools and while the water is still hot, disperse the solution into the pond. In a large pond, this is not practical. Then use the second method. This is putting lime in a sac or basket, hanging the sac on the side of a boat, then running the boat back and forth in the

pond slowly so that the lime is distributed into the pond more or less evenly. The next morning, the bottom mud should be stirred up to enhance the effect of pest control. Application in a non-drained pond has proved to be more effective and more labor-saving than that in a drained pond.

iii. Effects of lime application. (i) It kills residual pest fishes, frog eggs, tadpoles, aquatic insects, snails, crabs, shrimps, filamentous algae and shallow rooted plants, disease causing parasites and bacteria, etc. (ii) It clarifies pond water and precipitates colloidal organic matters. (iii) It fertilizes the pond by liberating nitrogen, phosphorus, potassium, etc. from the mud. (iv) In water, lime becomes calcium hydroxide. By absorbing carbon dioxide, it becomes calcium carbonate, which causes the mud to be more porous and therefore more ventilated and thereby hastens the decomposition of organic matter by bacteria. Also, together with dissolved carbon dioxide and carbonic acid, it serves as a buffer to maintain pH value, keeping it slightly basic, which is beneficial to fish. (v) Calcium is an indispensable ingredient for green plants and animals.

(2) Application of Camellia seed residue. This is the residue from pressing for oil the fruits of Camellia sasangua or C. semiserrata. The residue comes in the shape of a large cake; it contains saponin and acts as a blood dissolving toxin.

Camellia residue is commonly used by fishermen in Kwangtung and Kwangsi provinces. About 500 kg/ha per meter of depth is used. Break the cake into small pieces and soak in water for 24 hours (water temperature around 25 C). Greatly dilute it before adding it to the pond.

Camellia residue can kill pest fish, frog eggs, tadpoles, snails, and some aquatic insects. But it is not effective against bacteria. On the other hand, it helps the growth of green algae, which is not easily digested by fish. Camellia residue is therefore not as good an agent as lime.

(3) Application of Croton tiglium. The fruits of this plant contains crotin, a toxic albumen, which can kill fish. It is also toxic to man. Some people who are more sensitive to this toxin may suffer a swollen face and extremities upon contacting or breathing the fumes.

The effect of crotin is poor. It can only kill pest fish, but cannot kill parasites, bacteria, frog eggs, tadpoles, or aquatic insects. The increase of plankton in the first 7-8 days is even greater than in ponds that are treated with lime or Camellia, but plankton rapidly declines thereafter. Therefore, crotin does not improve the water quality.

(4) Application of bleaching powder. Upon hydrolysis, the bleaching powder becomes a strong bactericidal agent.

Bleaching powder has been used in the Soviet Union to clean fish ponds for a long time. It has been adopted in China only in recent years. First dissolve the bleaching powder in water, then immediately distribute the solution into the pond. generally, five days should be elapsed before fish planting.

Important things to remember in connection with using bleaching powder are as follows: i. Bleaching powder must be stored in an air tight porcelain container in a cool, dry place. ii. Use porcelain or wooden vessels to handle bleaching powder. Don't use metal containers, as metals will be oxidized by the powder. iii. Workers handling bleaching powder should use mouth mask to avoid breathing the fume. Also avoid contacting clothes with the powder.

The effects of bleaching powder are: i. It can kill fish, frog eggs, tadpoles, snails, some mussels, aquatic insects, parasites, and bacteria. In this respect bleaching powder is equal to lime. ii. The amount required is small and pond recovery is fast. iii. The disinfectant effect is closely related to fertility of the pond. The more fertile the pond, the smaller the effect.

(5) Application with rotenone. Rotenone is contained in legumes, Derris leguminosus Rozle and D. elliptica Benth. It is extracted from the roots of these plants. It is yellowish, and can be dissolved in organic solvents. It can kill fish and aquatic insects.

The effective concentration is 2 ppm. Use 20 kg/ha per meter depth. In use, dilute to 10-15 times, then spray into the pond.

Rotenone has no effect on plankton, parasites, or bacteria.

(6) Application of DDT. In recent years, a few places have used DDT to clean fish ponds. The method of application is similar to that of bleaching powder.

The effects of DDT are: (1) It kills fish and aquatic insects. (2) It has no effect in controlling diseases or improving bottom mud conditions. Its residue inhibits the reproduction of planktonic animals and adversely affects the growth of fishes.

(7) Combined use of lime and Camellia. For each acre-foot of water, use 50 kg/ha of lime and 270 kg/ha of Camellia. First soak Camellia in water and smash it, then add the whole mixture into lime. When lime is completely dissolved, disperse the solution into the pond. In a week, test the water with 10 bighead. If the fish survive after 8 hours, the pond is ready for fry planting.

Theoretically, the combined use of lime and Camellia should be effective. But much study is needed to show whether it is economical or whether the ingredients of the two substances would counteract each other and cancel their effects.

(8) Combined use of lime and bleaching powder. For each meter of water depth and ha of pond, use 30 kg of bleaching powder and 70 kg of lime. Planting can be done 10-12 days after application.

The effect seems to be better than either of the two substances used alone.

The effects of the various chemicals can be summarized as follows:

i. The effect of eliminating trash fish and disease control. The best chemical to eliminate trash fish is lime; Camellia and bleaching powder are next; rotenone, Croton, and DDT are least effective. As far as killing parasites and bacteria, bleaching powder is the most effective, lime is next. Croton is useless and Camellia can promote the growth of bacteria.

ii. The effect on productivity. Lime can increase the production of fish, because it can improve the bottom mud, accelerate the decomposition of organic matter, and at the same time serve as a source of calcium.

iii. Effect on macro-organisms. Again the most effective is lime, next is bleaching powder. Rotenone, Croton, and DDT are noneffective. Aside from killing most aquatic animals, lime can also eliminate algae and some tender aquatic vascular plants.

iv. Effect on plankton. Initially, lime, bleaching powder, and DDT will kill plankton. But 4 days after lime, bleaching powder, and DDT will kill plankton. But 4 days after lime application, and 2 days after bleaching powder application, plankton is on the rise. And 8 and 6 days after, respectively, plankton peak is reached. In the case

of DDT, plankton starts to grow again 8 days after application. Plankton increases also after Camellia application, but the increase is rather slight. Croton has an opposite effect: it enhances plankton growth at first, but after 2 or 3 days, plankton decreases. After lime application, plankton life is consistently kept at a high level and for a long period. In this regard, it is followed by bleaching powder and Camellia. Croton, rotenone, and DDT are poor.

v. Effect on pH. When lime is first applied, pH rises above 12. But within 24 hours it rapidly drops and then followed by gradual decrease. When it gets to around pH 9.4, zooplankton reproduce rapidly. Bleaching powder and Croton increase pH somewhat, but its effect on plankton growth is not determined. No change of pH has been detected after Camellia application.

The Rearing of Fry

Because fish fry are too small (6-9.5 mm), not being capable of active movement, having narrow feeding habits, and not well adapted to environmental hazards, they must be artificially reared before being planted in a pond. In general, a 15-25 day rearing period is needed when they attain a length of about one inch. At this stage, they are called "summer seed". Proper rearing of fry requires skill and technique, and is essential to the success of fish culture.

Main Features of Living Habit of Fry and Summer Seed of Six Domestic Carps

1. Food habits. Newly hatched fry rely upon their egg yolk as nutrient. When the yolk becomes absorbed, fry start to feed on planktonic organisms. Observations shows that at the beginning they feed on zooplankton, and later a greater variety of foods are eaten. Details are listed in Table 2.

Two points should be explained:

(1) In discussing food habits, we must take into consideration the environment in which the fish live. The species and abundance of plankton in a fish pond are reflected in the food contents of fish fry.

(2) The natural foods of fry and seed fall into two categories: preferred food and obligatory food. Fish select their preferred food when there is ample supply of food; they feed on obligatory food when there is scanty supply of food. The foods listed in table 2 are mostly preferred kinds, for stomach analyses are based on pond conditions where natural foods are plenty.

The question of nutrition through osmosis by fish fry should not be neglected. According to Karlsinkan, inorganic salts can permeate into the body of carp through the gills and oral membrane. The possibility of osmotic nutrition in fish fry is quite good and the question should be carefully studied.

Table 2. Food habits of six cyprinid fry and summer seed.

Length mm inches	Grass carp	Black roach	White bighead	Striped bighead	Common carp	Cirrhnina molitorell
0.236 6	--	--	--	--	Rotifers	Rotifers, daphnias
0.276-0.354 7-9	Rotifers, non-segmented larvae	Same	Same	Same	Rotifers, daphnia	--
0.394-0.421 10-10.7	Daphnia	Same	--	--	Daphnia, rotifers	--
0.433-0.453 11-11.5	--	--	Rotifers, daphnia, copepods	Rotifers, daphnia	--	--
0,484-0,492 12.3-12.5	Daphnia	Same	Daphnia, rotifers	Same	--	Rotifers, organic matter
0.551-0.591 4-15	--	--	--	--	Daphnia, benthic asnimals	Phyto-plankyon, organic matter
0.591-0.669 15-17	Daphnia, Benthic animals	Same	Rotifers, daphnia	Same	--	--
0.709-0.906 18-23	Ditto	Ditto	--	--	Daphnia, benthic animals	--

Table 2 CONT'D.

Length mm inches	Grass carp	Black roach	White bighead	Striped bighead	Common carp	Cirrhina molitorella
0.877-0.906 21-23	--	--	Rotifers, daphnia, copepods, phyto-plankton	Same	--	Organic matter
0.945 24	--	--	Phyto-plankton increased	Same	--	--
1.181 30	--	--	Mostly phyto-plankton	Same		--

2. Growth rate of fish fry. Under normal conditions, the increase in body length and weight in fry is fairly rapid.

As can be seen from Table 3, in 19 days, the grass carp increase in weight by 65.7 times, black roach by 42 times, white

Table 3. Growth of four cyprinid fishes.

Date	Grass carp			Black roach			White bighead			Striped bighead		
	L(mm)	Wt(g)	oz.	L(mm)	Wt(g)	oz.	L(mm)	Wt(g)	oz.	L(mm)	Wt(g)	oz.
	inches			inches			inches			inches		
May 3	8.52	2.80		8.58	2.85		8.64	3.18		9.61	4.9	
June 18	21.01	187		19.15	124		29.3	521		26.6	409.6	

bighead by 162 times, and striped bighead by 82.6 times. However, when food is deficient, fish fry will rapidly become emaciated and eventually die. Realizing this, fishermen usually inspect their fish ponds two to three times a day to make sure that food is not lacking.

3. External characteristics of four domestic carps. In fry that are 1.2-2.2 mm in length, major differences among the different species are as follows. The grass carp and black roach can be distinguished from the two bigheads by the absence of black pigments on the ventral finfold. The grass carp is distinguished from black roach by the shape of a network of pigments on the lower corner of the base of caudal fin. In the former, this network is in the form of a round spot and is lighter in color, whereas in the latter, it is elongated and is darker. The white bighead differs from striped bighead in having distinctly arranged pigments on the ventral

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finfold. In the striped bighead, these pigments are not as dense, and are scattered and less distinct. At the summer seed stage (about one inch), the grass carp is golden yellow in color, with distinct scales and a more blunt snout. The black roach is greenish yellow, with indistinct scales, and has a more pointed snout. The white bighead is silvery white; the ventral ridge extends from anus to the pectoral region; pectoral fins extend to the base of ventral fins. The striped bighead is golden yellow in color; the ventral ridge is present only between anus and ventral fins; pectoral fins long, extending over the basal part of ventral fins.

4. Distribution of four domestic carps in a fish pond. When fry are first placed in the pond, they are more or less evenly distributed. However, when they grow to about 1.5 mm in length, their distribution covers different food habitat. Grass carp and black roach are gathered near shore areas where larger planktonic animals and benthic animals are more abundant. The two bigheads live in the upper layers of the middle of the pond.

The Selection of a Fry Pond

In selecting a pond to raise fish fry, the environmental conditions must satisfy the biological characteristics of the fry and the feeding and harvesting requirements. Selecting conditions are as follows.

(1) Ample water source. During the course of fry culture, new fresh water must be added from time to time in order to

maintain the water quality. Therefore, the fry pond should be located near the source of water so that it is convenient to add water.

(2) Appropriate size and depth of pond. Generally a fry raising pond is from 0.152 to 0.758 acres in size and never exceeds 1.515 acres. If the pond is too large, it is difficult to manage, to add water, etc. Also, it is easily affected by wind, and the waves will injure fry. On the other hand, when the pond is too small, then environment induced changes will be too big.

In pond depth, requirements vary according to localities. In Kiangsu, Chekiang, and Kwangtung, 3-6 foot deep ponds are more suitable. In Hupeh, Kiangsi and some other provinces, ponds are generally 1.5-2.5 feet deep. When ponds are too shallow, water temperature and water quality can fluctuate violently due to environmental influence. When ponds are too deep, they are too expensive to fertilize, and water temperature is usually too low. Generally speaking, 3-6 foot deep ponds are more appropriate.

(3) Regular shaped ponds. In a regular shaped pond, it is easy to harvest by seining; it is also easy to feed and manage.

(4) Non-leaking. If there are cracks and leaks, fry will tend to gather there and swim against the flow, thereby affecting feeding activity. It is also more difficult to maintain proper volume of water.

(5) Level bottom. The pond bottom should be relatively level, and covered with only a small amount of mud. Too much mud will cause turbidity during seining. Mud also contains organic matter and causes oxygen depletion. It will produce hydrogen sulfide and marsh gas which are injurious to fish. A certain amount of mud, say 2-3 inches, is beneficial, because it provides the necessary adjustment of fertility for the pond.

(6) Plenty of sun light. The main food of fry is plankton, which depends upon the sun light for growth. Strong sunshine also keeps water temperature up, which is beneficial to the growth of fish.

The Rearing of Cyprinid Fry

According to Chinese classical literature, the Chinese people started in the Sung Dynasty to catch fish fry from the rivers and rear them in ponds. Because of the poor communication, there was little exchange of experience among fish culturists in various localities, and as a result, culturing methods vary widely from place to place. The most typical methods are those used in Kwangtung and Kwangsi provinces where green grass is used as fry food, and those used in Kiangsu and Chekiang provinces where soybean milk is used. Today fish culturists originated from these two areas are distributed over the entire country, exerting a great influence with their traditional methods. In the following, we therefore introduce, in brief, the essentials of the fish fry culturing methods that are practiced in these two areas.

1. The green grass feeding method of Kwangtung and Kwangsi. By this method, green grass and cow manure are mixed and then placed in fish pond. As they decay, they fertilize the water and promote the growth of plankton, which are eaten by fish fry. Where grass carp and Cirrhina molitorella are raised, peanut cakes are added after the third day.

(1) Preparatory work

i. Pond cleaning. Generally tea cake residue is used for pond cleaning. In order to exterminate Diphylobothrium tapeworm, the pond should be cleaned 50 days before fry are introduced. A second treatment should be made 10 days before fry are introduced. Then, the day before fry introduction, some 666 powder is added to kill off detrimental insects. In areas where no tapeworm disease is present, only one treatment (10 days before fry introduction) is sufficient.

ii. Fertilization. From 5 to 10 days before fry introduction, the pond can be fertilized with green grass. In Kwangtung, this is usually several species of compositae. Actually, some legumes or any other nontoxic, tender-leaved plants that decay easily can be used just as well. The grass is gathered in bundles which are placed in lee side of the pond in shallow waters about 1 or 2 feet away from the shore. In due time the grass will decay. The grass bundles should be turned over in a day or two. When the leaves and young stems are deteriorated, the residual stems and roots can be removed. If cow manure is used, the manure is diluted with

water, and the mixture is evenly spread over the surface of the pond. The amount of fertilizer to be used depends upon the fertility of the pond, the fish species to be cultured, and the quality of grass used. In general, 1.76-3.51 kg of grass are used for each hectare of pond. If the grass is of inferior quality (difficult to decay), then the amount should be increased. After the introduction of fish fry, depending upon the water quality, the pond should be continually fertilized.

iii. Water quality testing fish. To test whether the fertility of water in the pond is suitable, 200-300 young (about 4") striped bighead are placed in the pond several days after green grass has been added to the pond. The purpose is two-fold: one is to test the fertility of water. If the test fish surface for a short time every morning, it is an indication of suitable water quality. If they surface for an unduly long time, it is a sign of over fertility. And if they do not surface at all or seldom surface, then the water is not fertile enough and more grass should be added. If the pond is used to raise grass carp, then the surfacing of the test striped bighead should last no longer than 2 or 3 days. The other purpose of using the test striped bighead is to let them feed on the larger zooplankton (such as the Daphnias). Larger planktonic animals cannot be used by the small fish fry, and they help to deplete dissolved oxygen.

Aside from using the striped bighead as the testing fish, fishermen in Kwangtung and Kwangsi also use grass carp as the

test fish. The grass carp can remove filamentous algae. A recent study shows that two-year-old grass carp can be a carrier of tapeworm and can transmit the disease. It is therefore no longer recommended as a test fish.

Before fry planting, all test fish must be removed. If after 10 days or so of testing, fry planting still has not been carried out, then 1 metric ton of green grass should be added to each hectare of pond.

(2) Fry planting. In Kwangtung and Kwangsi, the fish fry that are collected from the river are sorted out by species through sieving, separation, etc. and reared separately.

The rearing density varies according to species reared. In general, for the white and striped bigheads, 450,000 to 600,000 fry are planted in each hectare of pond; for grass carp, 300,000 to 450,000 for the common carp, 450,000 - 800,000; for Cirrhina molitorella, 500,000 - 1,000,000. Besides, the density can be varied somewhat according to the condition of fry and the season in which fry are planted. In early season, the density can be bigger; in late season, smaller.

(3) Rearing and management.

i. Rearing methods. The methods differ according to species reared:

(i) The rearing of the white and striped bigheads. Two to three days before planting, place 1.5-2.0 metric tons of green grass in each hectare of pond. The day after planting,

fry will surface - about 2-3 hours a day. If they do not surface, more grass should be added. Thereafter, grass should be added every two to three days. The purpose of having to have fry surface is to eliminate pest species that may be mixed in the collection. The pest species are less tolerant to low oxygen, and they will die of asphyxiation under conditions where the bigheads surface. In 6-7 days, fry will grow to 1.6-1.9 cm in length. At this time they should be netted out, and the two species separated and reared in separate ponds in which large amounts of plankton have already been cultured. They can be reared here until they are 3 cm long.

The white and striped bigheads can be separated by sieving if they are of different sizes. However, when they are similar in size and cannot be separated by sieving, they can be managed in the following manner. Place the fry in a boxed net for 4 or 5 hours. Then place some food near the shore, and release the fry from the box. The white bighead, being more active and stronger, will eat most of the food and consequently will grow faster. In a day or two, the sizes of these two species will become different and they can be separated by sieving. If not, the process can be repeated once or twice.

(ii) Rearing fry of grass carp. From 1.5-2 metric tons of greens should be added into the pond per hectare every three days. Also, starting from the third day, 500-700 kg of

cow manure should be added. 100-200 kg of peanut residue cake should be added to each hectare every day. In 10 to 15 days, grass carp fry can grow to 2.5-3.0 cm.

(iii) Rearing of fry of Cirrhina molitorrela. Fertilize the pond as in grass carp pond. Generally, it requires one full month of growth before the fish can be taken out for culturing in an adult pond.

(iv) Rearing of fry of common carp. The common carp are reared from the eggs. At the time eggs are placed in the pond, greens can be added. Other fertilizers can be added after the eggs hatch. In 15-20 days, carp fry can grow to 2.5-3.0 cm.

ii. Pond inspection. Fry pond should be inspected once every morning and once every afternoon. Observe carefully water coloration and behavior of fry (whether surfacing or not) in order to decide whether fertilization is needed.

iii. Insect and disease control. In using green plants as a fertilizer, various kinds of insects are introduced and they are injurious to fish fry. Other diseases such as gill fungus, rotifers, tapeworms, etc. also can occur and they must be controlled at an early date.

(4) Hardening and transfer. After being reared for 15-20 days, fish fry grow into 2.5-3.0 cm summer seeds. At this stage, they feed actively and demand more space. They must be removed and reared in separate new ponds. Before doing so, they should be hardened as follows:

i. Method. Select a clear day when the fry do not surface. At about 9-10 A.M. seine the fry into a cloth net. Care must be taken to avoid getting debris into the net. In the cloth net, fry are concentrated in a dense school. At about 2 P.M., they are usually hardened enough to be transferring; sometimes, however, a second hardening is called for if the fry are not hardy enough. Also, if the seeds are to be transported to a distant place, then not only a second hardening is required, but also a further lean-water treatment is recommended. By lean-water treatment fish are removed from the rearing pond and placed in cloth containers in an unfertilized pond over-night. By the next morning, they are ready to be transported. (See Figures 1 & 2)

ii. The purposes of hardening. First, when disturbed, fish secrete a large amount of mucus, which is harmful. After being hardened once or twice, fish become adapted to high density, and will reduce mucous secretion during transportation.

Second, in 15-20 days, fry grow rapidly, increasing their body weight by up to more than one hundred times. Body tissue contains a high percentage of water. By concentrating the fry in a cloth container during hardening, the water content of body tissue is greatly reduced and the muscles are hardened, making the fish much more tolerant to transferring and transporting.

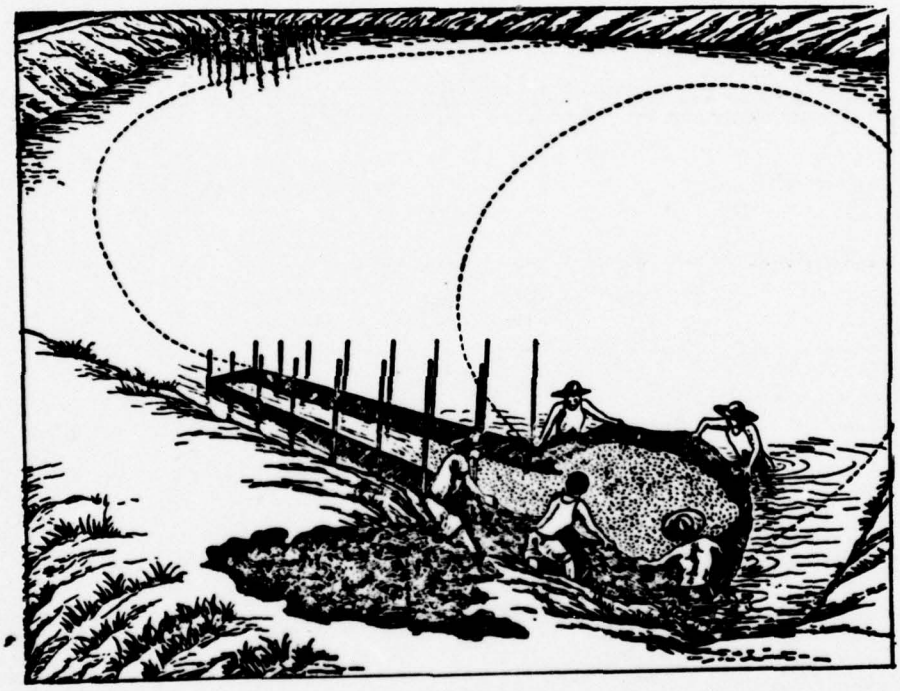

Figure 1 - Hardening of Fish Fry

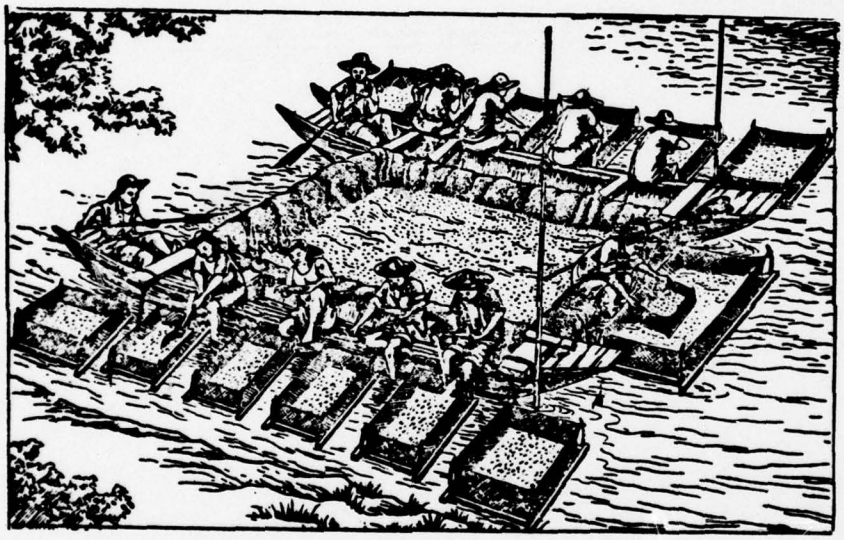

Figure 2 - Transfering of Fish Fry

Third, when fry are confined in dense schools, all their feces are deposited, which is desirable for transportation purpose.

2. The soybean milk feeding method of Kiangsu and Chekiang.

(1) Preplanting water change. After the rearing pond has been treated, it should be drained about three days before fry are introduced. Debris, harmful organisms (water scorpions, tadpoles, etc), and large plankton animals are removed from the bottom. Then, fresh water is added through a gunny sack filter. This is to prevent injurious fish and eggs from entering the pond. Water should be filled to about 2.5 feet.

(2) Fry planting. As soon as fry arrive, they should be immediately placed in the rearing pond regardless of the time of day. To each hectare of pond, 700,000-900,000 fry can be planted. A bamboo sieve is used to sieve out large sized harmful fishes.

Water temperature differential between fry water and pond water should not be more than 4 C. Feeding can be started soon after introduction of fry: when fry are planted in the morning or afternoon, soybean milk can be added the same afternoon; when fry are introduced in the evening, feeding can be done the next morning.

(3) Feeding method.

i. Preparation of soybean milk. First, soak the beans. The time of soaking depends upon water temperatures: 10-12

hours under 18 C; 6-7 hours under 25-30 C. Milk production is poor if the soaking is overdone or underdone.

When producing milk by grinding, beans and water must be fed into the grinding stone simultaneously. If water is added after grinding, precipitation will take place. After the milk is prepared, precipitation will take place if it is not used within half an hour. Generally, 2.5-3.0 pounds of soybean can yield 50 pounds of milk.

ii. Feeding frequency and method. Formerly, feeding was done twice daily. In recent years, the daily quota is divided evenly into three portions and fed thrice daily. In the morning, the soybean milk is fed into the pond first along the periphery of the pond and then over the entire pond. At noon, feeding is only along the periphery. In the afternoon about 2-3 P.M., repeat the morning feeding process. The main reason for this type of feeding procedure is to assure plenty of food for shore living fry of grass carp and black roach. Feeding should be temporarily suspended when it rains or when fry surface. If the pond is very fertile, only one feeding is enough for a day.

The soybean milk should be filtered; use the filtrate to feed fry. The milk should be spread over the entire pond evenly. In small ponds, this can be done from the shore; in large ponds, the milk can be dispensed from a boat. Each day, use a rope to skim off the surface foam.

iii. Quantity of feed. The quantity of milk to be used depends, not on the number of fry present, but on the size of pond. When fry are first introduced, use 50-75 kg/ha to each pond. Thereafter, the amount varies according to the color of water and to the growth of fry. In a continuing rain, when water temperature drops, a part of the milk will accumulate on the bottom, and plankton growth is slow. Under this condition, more milk should be added. Care should be taken, however, not to use too much milk, lest a sudden change of weather will start a plankton bloom and cause fish mortality.

iv. Additional feeding of soybean paste. After the application of soybean milk for more than 10 days, water becomes loaded with phytoplankton but plankton animals decrease in number. Grass carp and black roach cannot find enough large size planktonic animals to feed. These fish then gather in schools near the shore and swim wildly. To prevent this kind of condition from happening, soybean paste can be used as an additional feed. This is usually done by placing the paste in small grass leis which are tied to small bamboo poles in small grass bundles which are tied to small bamboo poles in shallow water. If this treatment does not work, then feed the fish with grain residue from wine making. The residue should be placed in shallow water (about half a foot deep) along the shore. Because the wine residue has a strong flavor, it seldom fails to attract fish.

(4) Pond inspection. The pond should be inspected twice a day; once in the morning and once in the afternoon. Remove undesirable weeds along the shore area, and get rid of frog eggs and tadpoles.

(5) Intermittent pond filling. This is an important step as learned from experience in Kiangsu and Chekiang.

During the entire raising period, water should be filled in 3 to 4 installments, each time adding 3 to 5 inches deep. Water is filtered through a gunny sack cloth to prevent pest fish from getting into the pond.

The advantages of installment filling of the pond are: When fish fry are first introduced into the pond, shallow water is beneficial to fish growth because natural food organisms breed faster due to rapidly rising water temperature. However, after a few days when the fish become much larger, water quality will deteriorate fast and dissolved oxygen drops considerably, especially during the night. The addition of fresh water increases oxygen content.

(6) Fry hardening and transfer. After 15-20 days of rearing fry grow to about 3 cm long. At this time they are ready to be transferred to new ponds for rearing. In order to avoid mortality during the transferring process, fry must go through the hardening procedure.

To test whether fry of white bighead are ready for hardening training, one can scare the fish by simply stomping on the shore or splashing on water surface to see if the

fry would leap out of water in groups. If they do, it means that they are ready in 2 or 3 days.

First hardening: Spread a seine across the entire width of the pond. Drag the seine from one end of the pond to the other. When nearing the half way point, feed some cooked soybean milk at the far end of the pond to attract the fish away from rubbing against the net. When seining is complete, gather the fish in the bagged net and leave them in the crowded condition for 10 or more seconds before releasing them back into the pond. Two hours later, feed some raw soybean milk. The next day, feed 5 or 6 times with cooked soybean milk.

Second hardening: If the fish act normally after the first hardening, and if the weather is good, the fish can go through the second hardening on the third day. Collect the fry in a seine net in the same manner as in the first hardening. But instead of releasing them almost immediately back into the pond, the fry are transferred into a box net, where they are held for half an hour before releasing. The fish should be fed with raw soybean milk the afternoon they are hardened; and fed 10-12 times with cooked milk the next day.

Third hardening and transferring: After the first and second hardening, and if the weather is good, the fish are usually ready to be transferred. If the weather is bad, then after a couple of days a third hardening is desirable before transferring.

In transferring the fry from the fry pond into new rearing ponds, the fish are collected into a box net. Then they are segregated into four boxes by species. Generally, the two bigheads grow faster, and they make up the major portion of the first transfer. The grass carp and black roach are smaller and mostly form the second transfer.

As the fish are segregated, pest species are removed. Also, the number of each species is estimated by the aliquot method.

3. Rearing with mixed fertilizers. Experimental studies have been made with mixed fertilizers in rearing fish fry. This method has been widely adopted throughout the country.

(1) Kinds of fertilizers and mixing formulas.

i. Green grass, 4 parts; sheep manure, 2 parts; human nightsoil, 1 part; lime, 1%.

ii. Green grass, 1 part; cow manure, 1 part; lime, 1%.

(2) Preparation. Dig non-draining, fermentation pits along the shore. Place green grass and cow manure in alternate layers in the pits; add lime solution (1 part of lime to 100 parts of total grass and manure) on top of each grass layer, and finally add enough lime solution to cover up all the fertilizer. Then seal the pits with mud and let fermentation take place. When the pits are opened for using, they should not be opened for any length of time, or nitrogen will be lost.

(3) Application of fertilizer. Three to five days prior to the planting of fry, apply fertilizer once or twice

at m(3) of water volume in the pond. From the day fry are planted, the pond should be fertilized twice a day at the rate of 120-160 g of fertilizer to each cu. m of water. Place the fertilizer in a sieve, wash the fertilizer into the water; then sprinkle the water evenly over the pond. Place the residue in the corners of the pond so that further fermentation and deterioration can take place.

In 1955, the Fisheries Research Institute of Academia Sinica conducted a fertilization experiment in Tang Pond in Chekiang Province. The pond is 0.273 acres in area and 4.265 ft. deep. On May 20, the pond was sterilized with 150 kg of lime. On June 8, 198,700 fry were introduced. The pond was fertilized twice a day, using the proportion of green grass 4: sheep manure 2 : human nightsoil 1.

After 23 days of rearing, the fish were taken out on July 1. There were 189,410 fry, a survival rate of 95.3%.

The pH of the pond was 7.3-9.2; water temperature ranged between 23.1 and 34.3 C, with an average of 27.1 C. Table 3.

Production of Zooplankton in Tang Pond

In 1957, another experiment was conducted in Hupeh Province. This time, different sizes of fish were segregated during the rearing process. When the fish were reared for 9 days, they were segregated into two groups by size by the use of sieving. The large ones, which were primarily the bigheads, were raised in one pond; and the smaller ones, which were mainly grass carp and roach, were reared in another pond. Both

Table 3. Growth rates of four domestic cyprinids in experimental pond.

Date	Grass carp			Black roach			White bighead			Striped bighead		
	Mean L. (mm) inches	Mean Wt. (g) oz.	Wt. inc. /day %	Mean L. (mm) inches	Mean Wt. (g) oz.	Wt. inc. /day %	Mean L. (mm) inches	Mean Wt. (g) oz.	Wt. inc. /day %	Mean L. (mm) inches	Mean Wt. (g) oz.	Weight increase/day %
June 8	8.1	.27	-	8.39	.240	-	8.35	.285	-	8.99	.450	-
11	-	-	-	-	-	-	-	-	-	10.12	.903	26.13
12	-	-	-	-	-	-	10.80	1.340	47.35	-	-	-
14	10.17	.95	23.44	-	-	-	-	-	-	14.2	5.14	78.55
15	-	-	-	10.03	.860	20.00	-	-	-	-	-	-
16	13.65	5.300	136.20	-	-	-	12.94	3.610	28.12	-	-	-
17	-	-	-	-	-	-	-	-	-	17.08	9.360	22.12
18	-	-	-	12.96	3.340	57.19	-	-	-	-	-	-
21	18.25	11.800	17.36	-	-	-	17.21	10.38	23.52	-	-	-
23	-	-	-	-	-	-	21.03	19.35	36.53	-	-	-
24	-	-	-	-	-	-	-	-	-	22.40	21.80	12.83
30	18.40	12.23	0.40	16.85	9.540	9.14	32.75	79.87	22.45	28.50	56.07	17.04

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12	-	-	-	-	-	-	10.80	1.340	47.35	-	-	-
14	10.17	.95	23.44	-	-	-	-	-	-	14.2	5.14	78.55
15	-	-	-	10.03	.860	20.00	-	-	-	-	-	-
16	13.65	5.300	136.20	-	-	-	12.94	3.610	28.12	-	-	-
17	-	-	-	-	-	-	-	-	-	17.08	9.360	22.12
18	-	-	-	12.96	3.340	57.19	-	-	-	-	-	-
21	18.25	11.800	17.36	-	-	-	17.21	10.38	23.52	-	-	-
23	-	-	-	-	-	-	21.03	19.35	36.53	-	-	-
24	-	-	-	-	-	-	-	-	-	22.40	21.80	12.83
30	18.40	12.23	0.40	16.85	9.540	9.14	32.75	79.87	22.45	28.50	56.07	17.04

ponds were sterilized with lime and fertilized. The ingredients and proportion of fertilizers were: green grass, 1; cow manure, 1; lime, 1%.

A total of 520,000 fry were reared. After 19 days, 480,142 summer seed were harvested, giving a survival rate of 92.33%.

Under such management, the environmental factors were favorable. pH was 7.6-8.7; average water temperature, 29.5 C; DO, 2.0-9.6 ppm; BOD, 8.4-14.2 ppm. The ponds maintained a high plankton life throughout. In one pond, the plankton volume was 2.7-38.9 g; in another pond, 2.2-36.9 g/m(3). Also, because the large and small fish were separated, each size group grew satisfactorily. Table 5.

4. Rearing with a mixing feed of organic fertilizer and soybean milk. In essence, this is a combination of the methods used in Kwangtung-Kwangsi and Chekiang-Kiangsu. Three to four days prior to fry introduction, fertilize the pond with cow manure-green grass. After fry introduction, feed with soybean milk daily.

The results of one experiment using the above method are as follows:

Pond, 0.175 hectare in area; water depth, 0.8 m.

April 25: Lime 235 kg, to cleanse the pond.

May 11: Green grass, 750 kg.

12: Cow manure, 500 kg.

18: Green grass, 135 kg.

23: Introduced fry 415,800.

Table 5. Growth rates of fish in experimental ponds.

Date	Grass carp			Black roach			White bighead			Striped bighead		
	Mean L. mm.	Mean Wt. g.	Wt. inc. /day	Mean L. mm	Mean Wt. g	Wt. inc. /day	Mean L. mm	Mean Wt. g	Wt. inc. /day	Mean L. mm	Mean Wt. g	Wt. inc. /day
May 30	8.52	.28	-	8.58	.285	-	8.64	.318	-	9.61	.490	-
June 2	-	-	-	10.03	.856	44.38	-	-	-	10.26	1.000	26.84
3	11.13	1.670	56.27	-	-	-	10.50	1.060	35.22	-	-	-
5	12.86	3.420	43.10	12.64	3.000	51.90	-	-	-	-	-	-
7	14.99	6.250	35.19	-	-	-	13.14	3.900	38.50	13.38	3.400	27.73
8	-	-	-	15.35	6.600	30.16	-	-	-	-	-	-
9	18.10	11.600	36.24	-	-	-	-	-	-	16.13	9.000	62.70
10	-	-	-	-	-	-	16.71	8.220	28.21	-	-	-
11	-	-	-	-	-	-	-	-	-	22.45	23.600	61.93
12	-	-	-	-	-	-	21.62	20.750	58.98	-	-	-
13	-	-	-	18.65	12.000	12.70	-	-	-	-	-	-
14	-	-	-	-	-	-	24.62	36.550	32.72	24.28	29.580	7.82
18	21.01	18.700	5.45	19.15	12.400	0.66	29.30	52.120	9.28	26.60	40.960	8.92

Daily feed, soybean milk and soybean, 3-9 kg. with one more addition of some cow manure.

Produced 353,050 summer seed. Survival rate, 84.91%.

In the entire process, total amount of soybean used, 91 kg; green grass, 885 kg; cow manure, 1644.5 kg. pH, 7.6-8.4; average water temperature, 27.5 C.

The growth rates of various fishes were: Black roach attained an increase rate of 29.24% before June 4; after that date, it dropped to 0.99%. In grass carp, the daily rate was 40.45% before June 31, after that, 10.49%; after June 7, it further dropped to 0.31%. In white and striped bigheads, the daily increase rate was 35.65% and 33.52% respectively during the early period (May 23 to June 3). After June 3, the rates dropped to 23.51% and 18.16% respectively.

5. Combination use of organic and inorganic fertilizers. This method is still in the experimental stage. The experiment conducted by Chekiang Freshwater Fisheries Institute in 1957 is briefly described below:

The experimental pond is 0.123 hectares; water depth, 1.8 m. The pond was drained April 22-24; treated with 150 kg of lime on April 25. Fertilized on May 20 with 106 kg of mixed manure (green grass 2: pig manure 4 : sheep manure 1 : human nightsoil 1 : lime 5%); 64 kg of sheep manure; 5 kg ammonium sulphate; 6 kg calcium phosphate. On May 22, 116,784 fry were introduced. They were fertilized once daily with the above fertilizers. In 18 days, 101,246 summer fry were produced, giving a survival rate of 86.65%.

During the entire rearing period, the following amount of fertilizers were used: mixed fertilizer, 1,433 kg; calcium phosphate, 35.42 kg; ammonium sulphate, 20.21 kg. In addition, added were fish meal, 0.5 kg; bean cake, 5 kg.

pH, 8.4; DO maintained at 5.3 ppm; BOD 11.11 ppm; phosphates, 0.03-1.7 mg/l; nitrates, 0.0336-0.25 mg/l nitrites, 0.005-0.0371 mg/l. Zooplankton counts were 20,000-588,000/l.

Experiments in which only inorganic fertilizers were used yielded poor results.

6. Utilization of sewage water to rear fish fry. This method not only saves fertilizers thereby lowering the cost, but also helps to solve the problem of sewage disposal in the city. The results of fish rearing in 1959 by using sewage by Academia Sinica's Fisheries Research Institute are described below. The pond which used organic fertilizers is given as control.

Both experimental and control ponds were 200 sq. m. in surface, 0.8 m deep, and were treated with lime 10 days prior to fish introduction. The main chemical ingredients of sewage are as follows (in mg/l):

pH, 7.2-7.4

Biochemical oxygen demand, 122-247

Inorganic salts, 6.30-17.86

Total phosphorus, 15-21.4

Ammonium N, 15.3-55.0

Nitrite N, trace

Nitrate N, 0.072-0.179

Organic N, 10.0-16.0

The sewage water was added into the pond every morning at the rate of 3 tons per 100 m of water surface.

The density of fry added was based on 100,000 fry per 0.805 hectare. The quality of fry was rather low, with roach accounting for 58%.

In 10 days (June 30 - July 10), 48 tons of sewage were added; 1,300 kg of organic fertilizers were used in the control pond.

Results are compared in Table 4.

Table 4. Growth rate of fry in sewage experimental pond and control pond (organic fertilizers).

	Grass carp		Black roach		White bighead		Striped bighead	
	L. cm	Wt. g	L. cm	Wt. g	L. cm	Wt. g	L. cm	Wt. g
Control pond	3.05	.3656	2.06	.107	3.16	.3350	3.82	.735
Exp't pond	4.09	.7180	2.34	.152	3.21	.4166	3.55	.532

Survival rate in control pond was 40.72%; in experimental pond, 43.42. There were also fewer instances of parasitism in experimental pond than in control pond.

Fry Rearing Problems and Discussions

1. Density of fry planting. Because the density of fry controls the quantity of zooplankton on which fry depend as food, the growth and survival are closely related to density.

Today the density of fry planting varies tremendously in various parts of the country, varying from several hundred thousand to more than 1 million per 0.6 hectares. Experience has shown that the survival rate was inversely proportional to density: the higher the density, the lower the survival rate. In one Chekiang experiment in 1957 with fry of four domestic carps, the results were as follows: Fry density of 319,000 per 0.5 hectare resulted in 40.83% survival; density of 280,000 yielded 68.38% survival; density of 180,000 fry per 0.5 hectare resulted in survival rate of 86.98%. Also, in the pond with the biggest density, fish were not uniform in size and were much smaller. Density experiment conducted by the Fisheries Research Institute in 1959 on carp fry showed similar results.

From the results obtained at various places, it seems that the most suitable density is around 990,000 fry to each 0.405 hectare of pond. If the species reared is Cirrhina molitorella, the density can be doubled, for these fish feed on detritus, and from a very early stage are slow growing. Besides, the density can be varied according to species composition, fish condition, and water quality. When there is a large proportion of bigheads, the density can be higher; when there is a large proportion of grass carp and black roach, the density should be lower. Density of early fry can be higher than that of late fry. Density in an old pond can be higher than that in a new pond.

2. The question of separate or mixed rearing. To have a clear understanding of this question, it is essential to know

the food habits of the various species of fry. Our preliminary observations reveal that grass carp and black roach, when 7-9 mm long, feed on rotifers, copepod nauplii, and Moina; when 10-14.5 mm long feed on larger Daphnias, copepods, and rotifers; when 15-18 mm long feed on large Daphnias; when 18-23 mm long feed on large Daphnias and some benthic animals. The bigheads feed on rotifers and nauplii when they are 7-9 mm long; on rotifers and small Daphnias when 10-11.5 mm long; on larger Daphnias and a few rotifers and nauplii when 13-17 mm long; on phytoplankton in addition to rotifers, Daphnias and copepods. When these fish reach 30 mm long, they feed less and less on zooplankton, and more and more on phytoplankton.

These four cyprinids, during their early stages, all feed on zooplankton. However, when they grow to about 15 mm long, their food habits begin to differ. Also, after a week or so of rearing, the quanity of zooplankton is greatly reduced but phytoplankton rises rapidly in number. Because of the difference in feeding intensity among the various species, the growth rate of the bigheads soon surpasses that of grass carp and black roach. For instance, after 23 days of rearing in a 1955 experiment by the Fisheries Research Institute of Academia Sinica, the total lengths of the four summer seeds were: grass carp, 2.42-2.84 cm; black roach, 2.09-2.53 cm; white bighead, 3.55-4.15 cm; striped bighead, 2.99-3.36 cm. In length, the former two are 1/5 to 1/4 shorter. In weight, the difference is far greater; the bigheads are 2-4 times greater.

From the above it can be concluded that before 15 mm in length, since the food habits of all species are the same, it makes no difference whether the different species are reared separately or mixed. However, after 15 mm, mixed rearing is not good for grass carp and black roach, and therefore they should be reared separately.

The Combined Methods of Fry Rearing

Each fry rearing method used in one place has its merits and demerits. By adopting the good points of each method and avoiding the disadvantageous practices, we suggest the following combined procedures:

(1) Pond cleaning. Stop all leakages; remove weeds along the shore. Treat the pond with lime 10-15 days prior to fry planting. Eliminate pest fish and other injurious animals.

(2) Screen out pest species among fry stock.

(3) Fertilize the pond once 3-5 days before planting in order to cultivate planktonic organisms.

(4) The day before introduction of fry, seine the pond to get rid of aquatic insects, frog eggs, tadpoles, etc. If necessary, treat the pond with 1% 666.

(5) Plant 100,000-150,000 fry to each 0.405 hectare of pond.

(6) When fry reach 15 mm in length, grass carp and black roach should be separated out from bigheads and reared separately.

(7) Fertilize the pond daily. In later stages, supplement with soybean cake and milk.

(8) Add water intermittently every few days. Each time add 3-5 inches of water to increase DO.

(9) Remove all injurious animals promply. Examine for the presence of parasites every 4-5 days; if found, control immediately.

(10) Harden the fry before transferring.